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Inferring Dense Confined Circumstellar Medium around Supernova Progenitors via Long-term Hydrodynamical Evolution

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Circumstellar interaction of supernova (SN) ejecta is an essential process in the evolution and observations of SNe have found the signature of circumstellar interaction both in the early and late evolutionary phase of SNe. Here we show that if the SN forward shock plunges into tenuous stellar wind from dense circumstellar medium (CSM) residing in the vicinity of the progenitor, the subsequent time evolutions of the SN-CSM interaction system deviates from the prediction of self-similar solution. In this case, the propagation of the forward shock will be driven by the ram pressure of the dense confined CSM component until it will be mostly compressed by the SN ejecta component, and the forward shock decelerates faster than the prediction of thin-shell approximation once the confined CSM component reaches homologous expansion. When the ram pressure of the SN ejecta can again act on the shocked shell consisting of tenuous wind component, the forward shock velocity recovers and the overall evolution converges to that without the CSM breakout. We also show that this peculiar evolution will be reflected in observational signatures originating from SN-CSM interaction, taking rapid decline and rebrightening of radio emission as examples. Our results shed light on the importance of taking into account the effect of initial SN-CSM interaction even when we focus on observational properties of SNe a few years after the explosion.

Section

High Energy

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